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Growth aspect of squid (*Loligo chinensis*) from the Banyuasin Coastal Waters, South Sumatra, Indonesia

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Abstract

Squid (*Loligo chinensis*) played an important role in small scale fisheries in Banyuasin Coastal Waters, however, the information and publications were limited. This study aimed to estimate the length at first capture ($L_{C50\%}$), the length at first maturity (L_m), growths pattern and condition factor of *L. chinensis* from Banyuasin Coastal Waters of South Sumatra. The squids were observed for samples in April 2018 and March 2019 using stationary lift net. During the observation, the squid measurement was conducted on 1179 individuals. The mantle length ranged was 40-210 mm and their body weight ranged was 2-42 gr. The value of $L_{C50\%}$, L_m and $\frac{1}{2}L_\infty$ were obtained at 103 mm, 147 mm, and 110.5 mm respectively. The analysis results of the length-weight relationship ($W = 0.0145L^{1.4618}$, $R^2 = 0.9265$ and $P < 0.05$) showed that their growth pattern was negative allometric ($b < 3$). The mean of relative condition factor ($K_n = 1.01$) above the critical value limits (K=0.56) confirmed that the environmental condition of Banyuasin Coastal Waters suitable for the *L. chinensis* growth. However, should be careful with their length

size of the squid catch were not feasible in the capture.

Keywords: Banyuasin, condition factor, growth pattern, *Loligo chinensis*

1. Introduction

Banyuasin coastal waters are strongly influenced by Sungsang estuary and have good fish diversity (Fauziyah et al., 2019). This area is essential for the local fishing community (Fauziyah et al., 2019, 2018) due to not only as maritime transport and settlement but as fishing center activities (Nurhayati et al., 2016; Sari et al., 2013).

In Banyuasin Coastal Waters, squid (*L. chinensis*) is the by-catch of fishing operation but it has high economic value (Fauziyah et al., 2013, 2012). The composition of squid catches using the fishing gear of stationary lift net in Banyuasin Coastal Waters ranged from 7-12% (Gustaman et al., 2012). On the other hand, in the Cirebon waters, the squid is the main catch of the "bouke ami" net with an average percentage of catch more than 50% of total fish landed (Puspasari and Triharyuni, 2013).

Although as a by-catch, due to its high economic value (Gustaman et al., 2012), squid plays an important role for the small scale fisheries in Banyuasin Coastal Waters and also in other waters in Indonesia such as Rembang (Puspasari and Triharyuni, 2013), Bangka (Oktariza et al., 2015) and Lampung (Yudha, 2011). In addition, using the stationary lift net, the squid was also caught by local fishermen in the Java Sea using pure seine and seine net (Puspasari and Triharyuni, 2013).

Besides squids play an important role in the small-scale fisheries, they play an important role in the marine food chain due to belong to the third trophic level in the

45 food chain (Emam et al., 2014). However, the information and publications on squid
46 fisheries in Banyuasin are limited therefore, a preliminary study on squid resource is
47 needed. One of them is the study of growth aspects such as: size distribution,
48 morphometric, length-weight relationship (LWR), condition factor, growth pattern, age,
49 life cycle, and growth parameters (Arkhipkin et al., 1998; Bat et al., 2009; Fauziyah et
50 al., 2016; Ferreri, 2014; Guerra and Castro, 2012; Muchlisin et al., 2014; Nuzapril et al.,
51 2013; Oktariza et al., 2015).

52 Some studies on the squid growth in the Indonesia waters had been conducted by
53 some authors such as biological characteristics of squid in the Java Sea (Puspasari and
54 Triharyuni, 2013), the LWR of squid in the Bangka waters (Bangka (Oktariza et al.,
55 2015), morphometric and condition factor of squid in Northern Coast of Central Java
56 (Nuzapril et al., 2013), the LWR and condition factor of squid in Northern Sea of Aceh
57 (Muchlisin et al., 2014). The LWR research can reflect population dynamics, growth
58 patterns, gonadal development and general conditions, and the body shapes
59 comparison from different fish groups (Sarma, 2015). The LWR was useful in fisheries
60 management for both basic research and applications (Shingadia, 2015) and as an
61 important tool in fisheries biology, ecology, physiology, conservation, and fisheries
62 assessment as well as water management and conservation (Hossain and Sultana, 2016;
63 Lawson and Olagundoye, 2011).

64 Very little is known about the growth aspect of squid in Banyuasin coastal waters.
65 The study aimed to estimate the length at first capture, the length at first maturity,
66 growths pattern and condition factor for the squid from Banyuasin coastal waters. The
67 study results are expected to be useful for the basis in the squid population management
68 in Banyuasin coastal waters.

2. Methods

The study was conducted at April 2018 and March 2019 in Banyuasin Coastal Waters of South Sumatra, Indonesia (Fig. 1). During the observation, the stationary lift nets (11 samples units in 2018 and 17 samples unit in 2019) were used. All measurements were conducted on the stationary lift net included mantle length (ML) and body weight. The estimation of the length-at first capture ($L_{C50\%}$) using the standard logistic curve method (Fauziyah et al., 2016; Saputra et al., 2010). The feasible fish size for capture was obtained by the ratio of the $L_{C50\%}$ value to the asymptotic length (L_∞). And other opinion used length-at maturity (L_m) as the critical limit value (Amponsah et al., 2016; Hoggarth et al., 2006). The mean length size of the fish capture had been feasible if the ratio ($L_{C50\%}/L_\infty$) > 0.5. The estimation of the L_∞ and L_m value was obtained by the formula (Amponsah et al., 2016; Hoggarth et al., 2006; Pauly, 1983) as follows:

$$L_\infty = \frac{L_{max}}{0.95}$$

$$L_m = \frac{2}{3} L_\infty$$

where L_∞ is the asymptotic length, L_{max} is the maximum size of mantle length from the squid catch, and L_m is the length-at first maturity.

The growth pattern was determined through the LWR analysis using the equation (Froese, 2006; Le Cren, 1951):

$$W = aL^b$$

$$\log W = \log a + b \log L$$

where W is the squid weight in grams, L is the squid mantle length in centimeters, log a

is the exponent describing the change rate of weight with length and b is the slope of the regression model or the allometric coefficient.

In order to determine the growth pattern, Bailey's t-test was needed (Nair et al., 2015; Thomas, 2013). The t-test was run to determine significant differences from the isometric value (b = 3) with significant level at 5% ($P < 0.05$). The formula of Bailey's t-test as follows:

$$t_s = \left|\frac{3-b}{Sb}\right|$$

where H_o is b = 3, H_1 is b ≠ 3, t_s is testing value b is regression coefficient of log-transformed data and Sb is the standard error of b. If the t_s value ≤ t_{table} indicated the isometric growth pattern whereas if $t_s > t_{table}$ indicated the allometric growth pattern. When the b value less than 3, their growth pattern was negative allometric. On the contrary, positive allometric if the b value greater than 3 (Benchikh et al., 2018; Sangun et al., 2007).

The relative condition factor (K_n) and Fulton's condition factor (K) were used in this study. The Fulton's condition factor was used for the isometric growth pattern whereas the relative condition factor for the allometric growth pattern (Nuzapril et al., 2013). Both condition factors were calculated based on the LWR results using the formula (Emam et al., 2014; Ferreri, 2014; Froese, 2006; Karnik and Chakraborty, 2001; Le Cren, 1951; Muchlisin et al., 2014; Nash et al., 2006; Nuzapril et al., 2013; Ricker, 1995):

$$K = 10^5 \frac{W}{L^3}$$

$$K_n = \frac{W}{aL^b}$$

where K is Fulton's condition factor, K_n is relative condition factor, W is the squid

weight in grams, and *L* is the squid mantle length in millimeters and 10^5 is the factor is used to bring K close to unity.

3. Result

3.1. The values of $L_{C50\%}$, L_∞ and L_m

The length-frequency data for 1,179 specimens of *L. chinensis* were used in this analysis. Mantle length (L) ranged from 40 to 210 mm and their weight ranged from 2 to 42 grams. The mean of the mantle length and their body weight were 105.5 mm and 13.5 gram respectively. The most specimens were found distributed in 101 to 110 mm (Fig .2). The L_∞ and $½L_\infty$ values observed were 221 and 110.5 mm respectively. The critical value for feasible capture was 110.5 mm. Fig. 3 showed the length at first capture ($L_{C50\%}$) of *L. chinensis* using the catch curve based on normal cumulative distribution. The $L_{C50\%}$ value was 103 mm which was smaller than the critical value ($½L_\infty$ = 110.5).

3.2. Length-weight relationship

The results of the LWR analysis were given di Table 1 and illustrated in Figure 4. F test showed that the mantle length diversity of *L. chinensis* can explain the bodyweight diversity simultaneously. Highly significant correlation coefficients values ($R^2 > 0.9$; $P<0.05$) were obtained for this squid indicated that a very strong correlation between mantle length and body weight. The LWR analysis obtained was $W = 1.4618L^{1.4618}$ and in the logarithmic formula could be written as Log W = 1.4618 Log L - 1.8391. The t_s value greater than t_{table} indicated that the b value significantly differs ($p<0.05$) from the

136 isometric value (b=3). And the b value < 3 exhibited the growth pattern of *L. chinensis*
137 was negative allometric growth.

138

139 ### 3.3. Condition factor

140 The result of Bailey's t-test had been indicated the allometric growth pattern for *L.*
141 *chinensis* in Banyuasin Coastal Waters. Therefore, the condition factor analysis
142 calculated by the formula of relative condition factor (K_n). The fluctuations of Kn values
143 were represented in Fig. 5. The K_n value ranged from 0.63 to 1.59 with the mean value
144 was 1.01±0.13. All of the K_n values were greater than the critical value (K=0.56)
145 indicated that the environmental condition of Banyuasin Coastal Waters suitable for the
146 growth of *L. chinensis*.

147

148 ## 4. Discussion

149 Besides being important as a fishery resource, squid is also an indicator of large-
150 scale oceanographic changes (Chen et al., 2007) and an important ecological species
151 (Jackson, 1998). There were at least 19 species of fish, 8 species of marine animals and
152 13 species of birds that were predators of squid (Jackson, 1998).

153 The squid *L. chinensis* is an Indo-Pacific species (Jereb and Roper, 2007) and one of
154 the cephalopods that are fast-growing mollusks (Aneesh et al., 2014). Cephalopods are
155 typically short-lived invertebrates and the lifespan of squid was estimated to average
156 about 1 year (Fang et al., 2016; Jackson et al., 1997; Jackson and Moltschaniwsky,
157 2001). Some tropical loliginids, including *L. chinensis* and *Loliolus noctiluca,* have been

158 reported to have the life cycle less than 200 days (Jackson et al., 1997). Variation in
159 food availability, geographic and ecology condition can affect the variation of growth
160 pattern (Chen and Chiu, 2003).

161 Compared with observation in the Java Sea (Nuzapril et al., 2013; Puspasari and
162 Triharyuni, 2013), the mantle length of *L. chinensis* in this study tended to attain larger
163 sizes but smaller than Bangka waters (Oktariza et al., 2015). The difference in the
164 mantle length will affect the L_m and $L_{C50\%}$ values. This present study showed that the
165 $L_{C50\%}$ value was smaller than both critical value (L_m and $\frac{1}{2}L_\infty$). It illustrated that the
166 majority of the catch constituted juvenile squid. This L_m value was almost similar to the
167 research in the Indian Ocean (Jereb and Roper, 2007). If L_m has occurred earlier and
168 $L_{50\%}$ was smaller, showed evidence of squid population induced outgrowth to earlier
169 maturation at smaller sizes. Maturity at length was positively related to fishery
170 abundance of squid and it was affected by the environmental condition (Pierce et al.,
171 2005).

172 The b value from the present study (b = 1.4618) was statistically significant from the
173 isometric value (b=3, $p<0.05$). The value was smaller than the others studies in the
174 Bangka Waters with the b value of 1.632 (Oktariza et al., 2015) and the Lamongan
175 waters (Mulyono et al., 2017) with the b value of 1.803. This result showed that the
176 weight of the squid populations in this study increased more slowly. It indicated that
177 squid populations in this study to allocate growth for reproductive tissue also more
178 slowly. This condition was not good in order to maintain their sustainable stock from
179 their high fishing pressure.

180 Based on the b value and Bailey's t-test for this study showed a negative allometric
181 growth and it was similar to study on *L. chinensis* from Bangka waters (Oktariza et al.,

2015), Lamongan waters (Mulyono et al., 2017), Central Java Waters (Nuzapril et al., 2013; Perangin-angin et al., 2015), Java Sea (Puspasari and Triharyuni, 2013). The negative allometric growth also reported for *Sepioteuths lessoniana* from Jaffna Lagoon, Sri Lanka (Sivashanthini et al., 2009), *S. lessoniana* and *Uroteuthis* sp. from northern sea of Aceh (Muchlisin et al., 2014) as well as *Loligo duvauceli* from Mumbay waters, west coast of India (Karnik and Chakraborty, 2001). In contrast, *L. vulgaris* from the Cadiz Gulf (Spain) showed positive allometric growth (Vila et al., 2010). In general, the cephalopods especially *Loligo* follows the allometric growth pattern (Karnik and Chakraborty, 2001). The negative allometric growth ($b < 3$) showed that the squid became lighter (Nair et al., 2015). The negative allometric growth may be due to the unfavorable condition (Nair et al., 2015).

Variation in growth pattern reflected the change in body squid that can be analyzed by the condition factor (Le Cren, 1951). If the growth pattern was the negative allometric, the 'K' value will tend to be decreased with increasing the mantle length (Emam et al., 2014) but it is not identical to the increase in size body (Zubia et al., 2014). The K value is the parameter of feeding condition (Le Cren 1951) or the fitness/wellbeing (Anene, 2005), and also useful for monitoring of feeding intensity, age and growth rates of fish (Sinha et al., 2018). The high the 'K' values indicated favorable environmental conditions otherwise low values indicated the unfavorable environmental condition (Blackwell et al., 2000). Opinion for the critical limit of the 'K' value differs between researchers. One opinion said that the fish condition was considered as wellbeing or good condition if the 'K' value ≥ 1 (Le Cren, 1951; Sachidanandamurthy and Yajurvedi, 2008; Sinha et al., 2018) and other opinions said that the fishes with the 'K' value > 0.56 were considered as in good condition (Bennet,

1970). The 'K' value in this study (K > 0.56) indicated that *L. chinensis* was in good condition of well-being. The 'K' value was strongly correlated to LWR, therefore, the b value was essential to assess the wellbeing of fish (Hamid et al., 2015). Therefore higher K indicated good feeding conditions for squid and it depends on seasonal changes and geographical differences.

5. Conclusion

This research provided basic information about the length-at first capture, length-at first maturity, asymptotic length, growths pattern and factor condition of squid *L chinensis* in Banyuasin Coastal Waters. The length average of this squid catch was not feasible due to the most catch constituted juvenile. The growth pattern of negative allometric had been observed in this study. The condition factor showed evidence this squid was in good condition of well-being but should be careful with the high fishing pressure and their length size of the squid catch were not feasible in the capture.

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Declarations of interest

None

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